ME562 – Spring 2020
Purdue University
West Lafayette, IN

Homework Set No. 3

Assignment date: Tuesday, February 11
Due date: Thursday, February 20, 11:59pm

- Please include this cover sheet as the first page of your homework submission.
- Submit homework file on Gradescope.

Name _____

PUID _____

Problem 3.1 _____

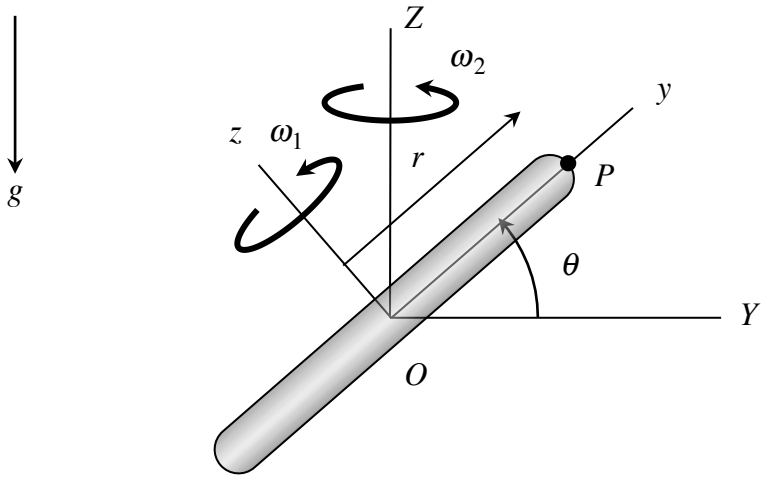
Problem 3.2 _____

Problem 3.3 _____

Problem 3.4 _____

TOTAL _____

Problem 3.1 – 30 points



A thrown Frisbee has two components of rotation: ω_1 about the body-fixed z-axis (axis of symmetry for the Frisbee) and ω_2 about the space-fixed Z-axis. As the Frisbee moves, the angle θ between the z and Z axes remains constant. In the absence of air resistance, the acceleration of the center of mass O of the Frisbee has an acceleration of g in the negative Z direction.

a) Determine the angular velocity and angular acceleration of the Frisbee.

b) Determine the acceleration of point P on the Frisbee.

Use the following parameters in your analysis: $\omega_1 = 10\,rad/sec$, $\omega_2 = 4\,rad/sec$, $\theta = 15°$ and $r = 6\,in$.

Problem 3.2 – 20 points

Consider an aircraft whose orientation is described by the TYPE I Euler angles defined in lecture. With the space-fixed and body-fixed axes initially coincident, the aircraft undergoes the following rotations:

$\psi = 30°$

$\theta = -60°$

$\phi = 50°$

a) Make a sketch of the aircraft in the final orientation.

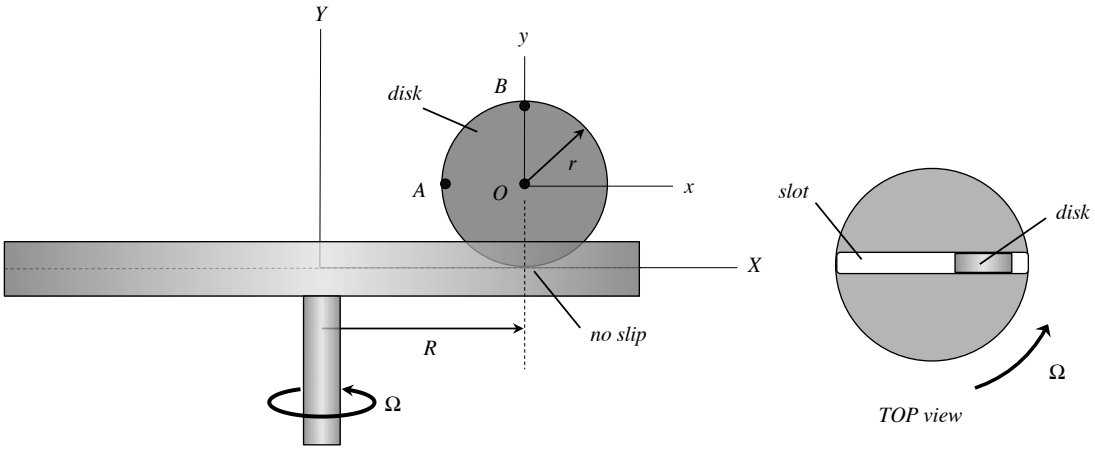
b) Determine the Euler axis of rotation and the corresponding angle of rotation.

c) Determine the direction angles of the fuselage in the final orientation.

d) Determine the direction angles of the right wing of the aircraft in the final orientation (assuming that this wing is aligned with the y-axis).

e) At some instant, the Euler angles are undergoing constant rotation rates of $\dot{\psi} = \dot{\theta} = \dot{\phi} = 0.5\, rad / sec$. At this instant, determine the body-fixed coordinates of the angular velocity and angular acceleration of the aircraft.

Problem 3.3 – 10 points

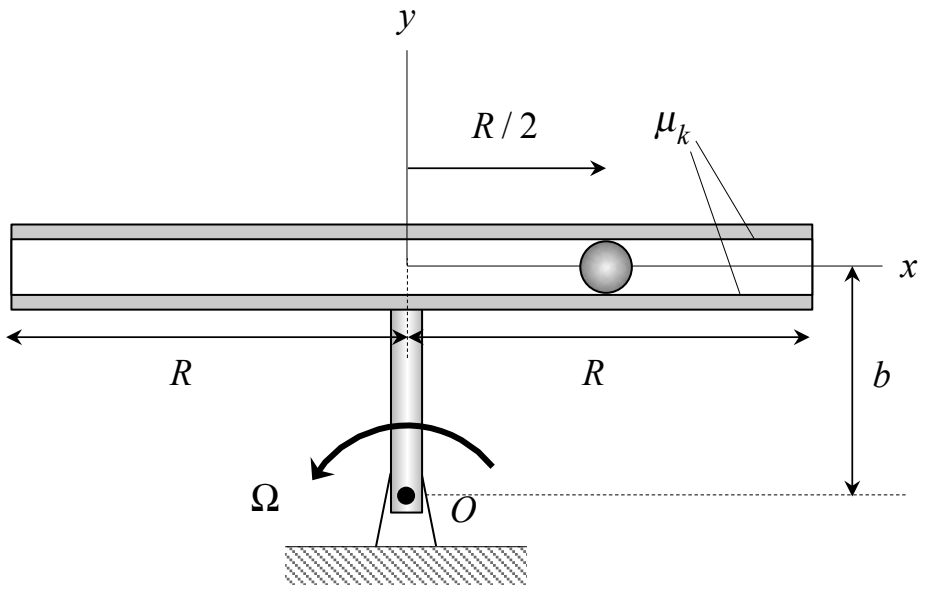


A turntable rotates about a fixed axis with a constant rotation rate Ω. A circular disk, having an outer radius of r, rolls without slipping within a radial slot cut in the top surface of the turntable in such a way that $\dot{R} = constant$, where R is the radial distance from the turntable's rotation axis and the center O of the disk.

a) Determine the angular velocity and angular acceleration of the disk.

b) Determine the acceleration of points A and B on the outer perimeter of the disk.

Problem 3.4 – 10 points



HORIZONTAL PLANE

A tube is attached to an arm with the arm being able to rotate about a vertical shaft passing through O. A particle of mass m is allowed to slide within the tube, with μ_k being the coefficient of sliding friction between the particle and the inner surface of the tube. The particle is released at rest relative to the tube at a radial distance of R/2 from the midpoint of the tube. The xyz axes are attached to the tube.

a) Determine the dynamic differential equation of motion for the particle in terms of its x-coordinate along the inside of the tube.

b) Determine the x-y components of velocity of the particle as it leaves the tube, assuming that the tube is smooth ($\mu_k = 0$).